3-03052-Y5

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Bibliography.

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(19) [Country of Issue] Japan Patent Office (JP)
(12) [Official Gazette Type] Open patent official report (A)
(11) [Publication No.] JP,6-243882,A.
(43) [Date of Publication] September 2, Heisei 6 (1994).
(54) [Title of the Invention] The protection halt method of a fuel cell power plant.
(51) [The 5th edition of International Patent Classification]

H01M 8/04 H
S

[Request for Examination] Un-asking.
[The number of claims] 3.
[Mode of Application] OL.
[Number of Pages] 6.
(21) [Filing Number] Japanese Patent Application No. 5-25865.
(22) [Filing Date] February 16, Heisei 5 (1993).
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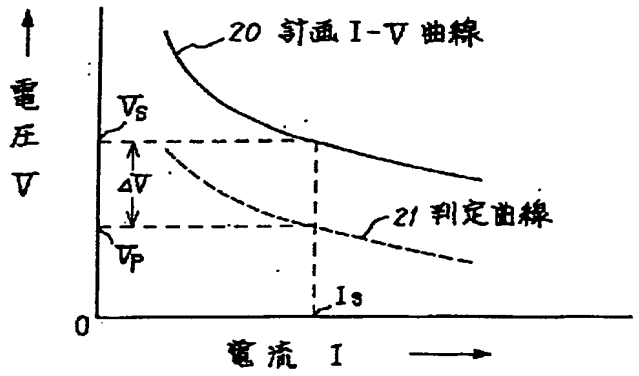
Summary.

(57) [Abstract]
[Objects of the Invention] Damage on a fuel cell is avoided by detecting the gas insufficient state locally generated in a fuel cell at the time of load-up instructions of a fuel cell at an early stage, and carrying out a protection halt.
[Elements of the Invention] A protection halt is carried out, when they are detected about two or more cell sections, having used two or more unit cells as the cell section and the minimum value of detection voltage carries out fixed sag of the output voltage of a fuel cell stack with respect to the size of load power that there is nothing. for example, the plan I-V curve 20 of the cell section — fixed voltage deltaV — the curve which carried out the parallel displacement to the low side — the judgment curve 21 of sag — carrying out — predetermined instruction power value Is xVs Voltage value pinch off voltage corresponding to the instruction power value on the judgment curve 21 in the receiving minimum value of detection voltage up to — when it falls, it judges with what the gas insufficient state generated, and a protection halt is carried out in the cell section

[Translation done.]



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CLAIMS

[Claim(s)]
[Claim 1] It is the method of detecting the gas insufficient state produced at the time of load-up instructions by the fall of the output voltage of the aforementioned fuel cell stack, and carrying out a protection halt in a fuel cell power plant, by which it is characterized by providing the following. The protection halt method of the fuel cell power plant characterized by carrying out a protection halt when they are detected about two or more cell sections, having used two or

more unit cells as the cell section and the minimum value of detection voltage carries out fixed sag of the output voltage of the aforementioned fuel cell stack with respect to the size of load power that there is nothing. The fuel cell stack which consists of a layered product of a unit cell. The fuel processing unit which supplies fuel gas to this fuel cell stack, and air supply equipment. The power converter which changes and outputs the output direct current power of the aforementioned fuel cell stack to load power. The control unit which carries out link control of each part of the above.
[Claim 2] The protection halt method of the fuel cell power plant according to claim 1 characterized by for the minimum value of cell section voltage to judge with what carried out fixed sag, and to carry out a protection halt when the curve which carried out the parallel displacement of the plan I-V characteristic curve of the cell section to the low side 1 constant voltage is made into the judgment curve of sag and the minimum value of detection voltage to a predetermined instruction power value falls to the voltage value corresponding to the instruction power value on a judgment curve.
[Claim 3] The protection halt method of the fuel cell power plant according to claim 1 characterized by for the minimum value of cell section voltage judging with what carried out fixed sag, and carrying out a protection halt when it asks for the average of the detection voltage of two or more cell sections, and the difference voltage of this average and each detection voltage and the maximum of the sum of the obtained difference voltage and the correction voltage which becomes settled for every cell section exceeds fixed voltage.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the protection halt method which a fuel cell power plant performs to the well which avoids the injury on the lack of gasoline by the short supply of fuel gas, and the fuel cell resulting from this in case [that] output power is gone abruptly up in response to load-up instructions on stream.
[0002]
[Description of the Prior Art] the fuel cell power plant containing the fuel cell stack 1 which drawing 5 is the common system configuration view of a fuel cell power plant, and consists of a layered product of a unit cell — a fossil fuel and hydrocarbon system fuel — the hydrogen as anode gas for fuel cells — it consists of the fuel processing unit 2 reformed to rich fuel gas, air-supply equipment 3 which supplies the air as an oxidizer to a fuel cell, a power converter 4 which changes the output direct current power of a fuel cell into the power of the form which an external load requires, a control unit 5 which control these each part
[0003] Thus, elevation of the supply voltage to the external load of the constituted fuel cell power plant which can be set on stream and descent A control unit 5 is controlled by the control signals 2S and 3S emitted towards a fuel processing unit 2 and air supply equipment 3 in

response to the fact that external change-of-load instruction 9S, and control signal emitted towards power converter 4 4S grade. The supply voltage to fuel gas, the amount of air supply, and an external load is controlled in agreement with each desired value corresponding to external change-of-load instruction 9S.

[0004] Although a power converter 4 tends to output the power corresponding to the instruction value by the speed of response below a millisecond when external change-of-load instruction 9S order it a load up on stream [the above-mentioned fuel cell power plant], a fuel cell 1 is controlled by the speed of response of a fuel processing unit 2 and air supply equipment 3, and delay generates it in the fuel gas to elevation instructions, and the increase in air supply. In addition, the speed of response of a fuel processing unit 2 and air supply equipment 3 is because the process of that late one includes the chemical reaction of the increase in the amount of reforming (increase in a reforming reaction) in the response process with the fuel processing unit and the mass transfer of the firedamp migration of a under [piping] is included compared with it of a power converter 4.

[0005]

[Problem(s) to be Solved by the Invention] When performing a load up by power control according a fuel cell power plant to external change-of-load instructions, the following problems occur. That is, if feedforward control of the fuel cell power plant is carried out by external change-of-load instruction 9S, a control unit will set up the desired value corresponding to external change-of-load instructions, will order a power converter 4 the output of the power corresponding to desired value by control signal 4S, and will order a fuel processing unit 2 and air supply equipment 3 the fuel gas and the air supply of an amount corresponding to desired value with control signals 2S and 3S. However, as mentioned above, for a low reason, compared with elevation of electrical output, a speed of response follows rapid load-up instructions, and the fuel gas and the amount of air supply to a fuel cell 1 do not increase, but a gas insufficient state generates fuel gas and air supply temporarily in the fuel electrode and air pole of a fuel cell 1.

[0006] the vicious circle to which a power converter 4 makes the output current of a fuel cell increase, and tends to double output power with desired value, and the voltage of a fuel cell 1 falls further owing to this since the power generation voltage of a fuel cell will fall once a gas insufficient state occurs in a fuel cell — generating — just — being alike — a fuel cell results in a lack-of-gasoline state In this case, since the delay of the temperature rise by the heat capacity of a fuel cell also has the temperature dependence of a power generation property in a fuel cell, it leads to the increase in the current at the time of a load up. Consequently, by the variation in the cross-section configuration of the reactant gas path formed in each electrode among the unit cells by which the laminating was carried out etc. The difference of gas ** which cell voltage is reversed from the unit cell to which reactant gas cannot flow easily, or joins inter-electrode increases, and the injury on a fuel cell, like the blow by of gas arises in inter-electrode occurs. The problem of progressing to the situation where continuous running of ********** becomes impossible at last detects ** and a gas insufficient state at an early stage, the generating mode of a fuel cell is stopped, and the establishment of the protection halt method which can prevent the injury on a fuel cell is called for.

[0007] In order for drawing 6 to be explanatory drawing of protection operation in the conventional protection halt method of a fuel cell power plant and to detect the gas insufficient state of the fuel cell stack 1 by the fall of the output direct current voltage As opposed to the plan I-V characteristic curve (plan current-voltage characteristic curve) 10 of the fuel cell stack 1 as the judgment curve 11 of a protection halt — the size of Current I — being concerned — there is nothing — fixed voltage VL setting up — output direct current voltage Vi of the fuel cell stack 1 Judgment level VL up to, when it falls It is judged as what the gas insufficient state generated in the fuel cell, for example, the output of a power converter 4 is extracted, and the method constituted so that a protection halt which stops power generation of the fuel cell stack 1 might be performed is learned. Moreover, the fuel cell stack 1 is classified into two or more cell sections which make two or more unit cells 1 block, the voltage of each cell section is detected, and it is the fixed voltage VL. How to collate and carry out a protection halt is also learned.

[0008] However, the judgment curve 11 of a protection halt start is the fixed voltage VL

regardless of the output current I of a fuel cell. Since it is fixed, when difference voltage deltaV=VO-VL (it is equivalent to the amount of falls of output voltage) with plan I-V curve becomes large in a low-current (low power) field and the shortage of gas arises in this field, the detection is long overdue and the problem that the injury on a unit cell is nonavoidable occurs. Moreover, when it constitutes so that the fuel cell stack 1 may be classified into two or more cell sections and voltage may be detected supposing the case where sag is produced only in the unit cell of the portion which exists transitionally, it becomes an obstacle that difference voltage deltaV is large in a low-current field, detection of the gas insufficient state in this field is long overdue, and the problem that the injury on a unit cell is fully nonavoidable occurs.

[0009] The purpose of this invention is by detecting the gas insufficient state locally generated in a fuel cell stack at the time of load-up instructions of a fuel cell at an early stage, and carrying out a protection halt to avoid the injury on a fuel cell.

[0010]

[Means for Solving the Problem] The fuel cell stack which consists of a layered product of a unit cell according to this invention in order to solve the above-mentioned technical problem, The fuel processing unit which supplies fuel gas to this fuel cell stack, and air supply equipment, In the fuel cell power plant containing the power converter which changes and outputs the output direct current power of the aforementioned fuel cell stack to load power, and the control unit which carries out link control of each part of the above It is the method of detecting the gas insufficient state produced at the time of load-up instructions by the fall of the output voltage of the aforementioned fuel cell stack, and carrying out a protection halt. When you detect them about two or more cell sections, having used two or more unit cells as the cell section and the minimum value of detection voltage carries out fixed sag of the output voltage of the aforementioned fuel cell stack with respect to the size of load power that there is nothing, suppose that a protection halt is carried out.

[0011] Moreover, when you make into the judgment curve of sag the curve which carried out the parallel displacement of the plan I-V curve of the cell section to the fixed voltage low side and the minimum value of detection voltage to a predetermined instruction power value falls to the voltage value corresponding to the instruction power value on a judgment curve, suppose that the minimum value of cell section voltage judges with what carried out fixed sag, and carries out a protection halt. Furthermore, when you ask for the average of the detection voltage of two or more cell sections, and the difference voltage of this average and each detection voltage and the maximum of the sum of the obtained difference voltage and the correction voltage which becomes settled for every cell section exceeds fixed voltage, suppose that the minimum value of cell section voltage judges with what carried out fixed sag, and carries out a protection halt.

[0012]

[Function] When the output voltage of a fuel cell stack carries out fixed sag with respect to the size of load power that there is nothing, the trouble of the conventional technology in which of the gas insufficient state in a low-current field is undetectable at an early stage eliminates, and the function of detecting a gas insufficient state at an early stage in all load fields, and preventing the injury on a fuel cell is obtained by having constituted so that a protection halt might be carried out in this invention's. Moreover, when the fall of voltage is detected about two or more cell sections and the minimum value of detection voltage carries out fixed sag by making two or more unit cells into the cell section, quick and the function to detect by high sensitivity and to prevent the injury on a unit cell are obtained also in the gas insufficient state generated in the limited unit cell by having constituted so that a protection halt might be carried out.

[0013] Moreover, the curve which carried out the parallel displacement of the plan I-V curve of the cell section to the fixed voltage low side is made into the judgment curve of sag. If it constitutes so that a protection halt may be carried out when the minimum value of detection voltage to a predetermined instruction power value falls to the voltage value corresponding to the instruction power value on a judgment curve While crossing the judgment level of a fixed voltage low protection halt to all load fields and being able to set it up with a sufficient precision based on plan to have been compensated as initial property of fuel cell stack I-V curve Since the protection voltage value corresponding to the instruction power value of power elevation

instructions can be easily chosen from on a judgment curve By performing a protection halt, when it falls to the protection voltage value as which the minimum value of the output voltage of cell section voltage was chosen The function in which how to decide the fixed voltage difference which generating with insufficient gas is detected at an early stage per cell section, and the function to prevent the injury on a unit cell is obtained, and is held between plan I-V curve and a judgment curve adjusts the grade of the gas insufficient state which carries out a protection halt is also obtained.

[0014] Furthermore, when it asks for the average of the detection voltage of two or more cell sections, and the difference voltage of this average and each detection voltage and the maximum of the sum of the obtained difference voltage and the correction voltage which becomes settled for every cell section exceeds fixed voltage, If it constitutes so that the minimum value of cell section voltage may judge with what carried out fixed sag and may carry out a protection halt It is based on the average of the detection voltage of each cell section which is in downward process in inverse proportion to the increase in the output power by load-up instructions. Detect the latest cell section of a power surge, and the variation factor of voltage [ease / of the cell temperature in the cell section and fuel gas / of flowing] is rectified by applying correction voltage. in addition — and, since a protection halt is carried out when the voltage difference (sag) over the average exceeds fixed voltage The excess-and-deficiency state of the distributed gas transitionally produced immediately after load-up instructions is supervised on real time for every cell section as transitional change of voltage. While the function which turns into that it is possible to perform a protection halt based on fine circumstantial judgment, detects the property fall of a cell local and with time quickly, and suppresses the injury on a cell to the minimum is obtained In the state where a protection halt does not start, the function to hold a fuel cell power plant to safe continuation operational status is obtained, without being anxious about the injury on the fuel cell by the shortage of gas.

[0015]

[Example] Hereafter, this invention is explained based on an example. The duplicate explanation is omitted, when explanatory drawing of protection operation in the protection halt method of a fuel cell power plant that drawing 1 becomes the example of this invention, and drawing 2 are the system configuration views showing the protection halt method which becomes an example and give the same reference mark to the same component as the conventional technology. In the protection halt method of a fuel cell power plant which becomes an example it is shown in drawing — as — the fuel cell stack 1 — two or more unit cells — a unit — carrying out — two or more cell sections 1a, 1b, and 1c and .. 1f etc. — 1i It classifies. two or more voltage detectors 22 — the voltage Va, Vb, and Vc of each cell section, and .. 1i, such as Vn, it detects. The set point pinch off voltage of the protection level which becomes settled beforehand about each detection voltage in the judgment section 23 It collates and is 9s of change-of-load instructions. In the process which increases rapidly, the output power of a fuel cell stack the cell section voltage Va, Vb, and Vc and .. Vf etc. — when either falls even to a protection level-setting value, it is constituted so that it may be judged as what the gas insufficient state generated in one of the cell sections and a protection halt may be carried out

[0016] In the case of this example, it is the set point pinch off voltage of protection level. As how to determine, as shown in drawing 1 , the curve which carried out the parallel displacement of this curve to the fixed voltage deltaV low side on the basis of the plan I-V curve 20 corresponding to initial cell section voltage is set up as a judgment curve 21 of sag. 9s of change-of-load instructions the predetermined instruction power value to depend — Is xVs ** -- the case where it carries out — current Is Voltage value pinch off voltage on the ****ing judgment curve 21 it sets automatically in the judgment section 23 as a protection level-setting value — having — the detection voltage Va, Vb, and Vc of the voltage detector 22, and .. Vf Protection level-setting value pinch off voltage It collates, respectively.

[0017] The output current of the fuel cell stack 1 is Is. It is Is about current in a small load field. 9s of increasing load-up instructions When it receives, A power converter 4 is ordered the output of the power corresponding to desired value by control signal 4S which a control section 5 (refer to drawing 5) emits. with control signals 2s and 3s ordering a fuel processing unit 2 and

air supply equipment 3 the fuel gas and the air supply of an amount corresponding to desired value — the output current of the fuel cell stack 1 — increasing — following — the voltage Va, Vb, and Vc of each cell section, and .. Vf Target voltage Vs It turns and changes. However, there is variation in the delay of the temperature rise of a unit cell, the variation of the cross-section configuration of a reactant gas path, etc. between the cell sections, the shortage of gas occurs in the unit cell with which the ill condition lapped, the fall width of face of the cell section voltage which includes this unit cell in connection with this becomes large, and the judgment curve 21 is approached. Therefore, the cell section voltage which was [this] gas insufficient is the set point pinch off voltage of judgment level. So that it may be in agreement If voltage difference deltaV of the plan I-V curve 20 and the judgment curve 21 is set up, while becoming possible to detect the minimum value of detection voltage at an early stage, and to carry out a protection halt of the fuel cell stack and being able to suppress the injury on a unit cell to the minimum In the state where a protection halt does not start, the protection halt method that the reliability which feels easy about a fuel cell power plant, and can carry out continuation operation is high is acquired. In addition, if fixed voltage difference deltaV held between plan I-V curve and a judgment curve is made adjustable, the advantage which can adjust the grade of the gas insufficient state which carries out a protection halt will also be acquired.

[0018] The system configuration view showing the protection halt method of a fuel cell power plant that drawing 3 becomes the example from which this invention differs, and drawing 4 are explanatory drawings of protection operation in the protection halt method which becomes a different example. drawing — setting — the fuel cell stack 1 — for example, 1a, 1b, 1c, and .. cell section voltage Va, Vb, Vc, Vd, Ve, and Vf which classified into the n cell sections, such as 1 etc.n, and was detected with the voltage detector 22, respectively etc. — the detection value of n pieces — the average operation part 32 — the average Vave =Va+Vb+Vc+Vd+Ve+Vf .. /n is called for Subsequently, it sets to the operation part 33 of sag, and is the average Vave of detection voltage. The amount of falls of each receiving detection voltage, and its amendment (Vave-Vi) +Vki (Subscript i shows the arbitrary cell sections) is calculated. However, correction voltage Vki is beforehand decided in consideration of the influence the difference of the initial condition of the temperature gradient between the cell sections, the ease of flowing of fuel gas, etc. affects cell section voltage. Moreover, calculation of the amount of falls of the above-mentioned detection voltage is Average Vave. It may be constituted so that it may carry out only to low detection voltage.

[0019] A calculation result is judgment voltage deltaVj which was sent to the judgment section 34 and was beforehand set as the protection level-setting machine 35. As it collates and is shown in drawing 4 , it is 1f of cell sections. (Vave-Vf) + Vkf>=delta Vj When it changes into the state of filling, it is 1f of cell sections. It is judged as what the gas insufficient state generated, and it is constituted so that the judgment section may emit protection halt instructions. Thus, it sets to the constituted protection halt method. The average Vave of the detection voltage of each cell section which is in downward process in inverse proportion to the increase in the output power by load-up instructions It is made criteria. the latest cell section (drawing 1f) of a power surge — Average Vave as a receiving fallen part of detection voltage — detecting — (Vave-Vi) And the variation factor of voltage [ease / of the cell temperature in the cell section and fuel gas / of flowing] is rectified by applying correction voltage Vki. in addition — and voltage difference over the average (Vave-Vi) +Vki — judgment voltage deltaVj Since a protection halt is carried out when it exceeds The excess-and-deficiency state of the distributed gas transitionally produced immediately after load-up instructions is supervised on real time for every cell section as transitional change of voltage. While the function which turns into that it is possible to perform a protection halt based on fine circumstantial judgment, detects the property fall of a cell local and with time, and suppresses the injury on a cell to the minimum is obtained In the state where a protection halt does not start, while being able to perform elevation of a load, and downward control, without being anxious about the injury on the fuel cell accompanying lack of gasoline or this, the advantage which can carry out continuation operation of the fuel cell power plant safely is acquired.

[0020]

[Effect of the Invention] When they were detected about two or more cell sections, having used two or more unit cells as the cell section and the minimum value of detection voltage carried out fixed sag of the output voltage of a fuel cell stack with respect to the size of load power as mentioned above that there is nothing, this invention constituted the protection halt method at the time of the load up of a fuel cell so that a protection halt might be carried out. consequently, the trouble of the conventional technology in which the gas insufficient state in a low-current field is undetectable at an early stage is eliminated, and while detecting a gas insufficient state at an early stage in all load fields and being able to prevent the injury on a fuel cell, quick and the protection halt method which is a fuel cell power plant that it detects by high sensitivity and the property fall of a unit cell can be prevented can be offered also for the gas insufficient state transitionally generated in the limited unit cell

[0021] Moreover, in the state where a protection halt does not start, while being able to perform elevation of a load, and downward control, without being anxious about the injury on the fuel cell accompanying lack of gasoline or this, the advantage which can carry out continuation operation of the fuel cell power plant safely is acquired.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Explanatory drawing of protection operation in the protection halt method of a fuel cell power plant which becomes the example of this invention
[Drawing 2] The system configuration view showing the protection halt method which becomes an example
[Drawing 3] The system configuration view showing the protection halt method of a fuel cell power plant which becomes the example from which this invention differs
[Drawing 4] Explanatory drawing of protection operation in the protection halt method which becomes a different example
[Drawing 5] The common system configuration view of a fuel cell power plant
[Drawing 6] Explanatory drawing of protection operation in the conventional protection halt method of a fuel cell power plant
[Description of Notations]
1 Fuel Cell Stack
1i Cell section
2 Fuel Processing Unit
3 Air Supply Equipment
4 Power Converter
5 Control Unit
9s Change-of-load instructions
10 Plan I-V Characteristic Curve
11 Judgment Curve

20 Plan I-V Characteristic Curve
21 Judgment Curve
22 Voltage Detector
23 Judgment Section
32 Average Operation Part
33 Operation Part of Sag
34 Judgment Section
35 Protection Level-Setting Machine
Vs Cell section voltage (instruction value)
Is Output current (instruction value)
Vp Protection level-setting value
deltaV Sag width of face (judgment voltage)
Vave The average of detection voltage
Vf Cell section voltage (detection value of 1f of cell sections)
Vkf 1f of cell sections Correction voltage
deltaVj Voltage drop width of face (judgment voltage)

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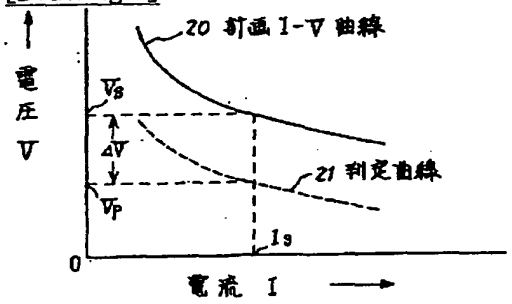
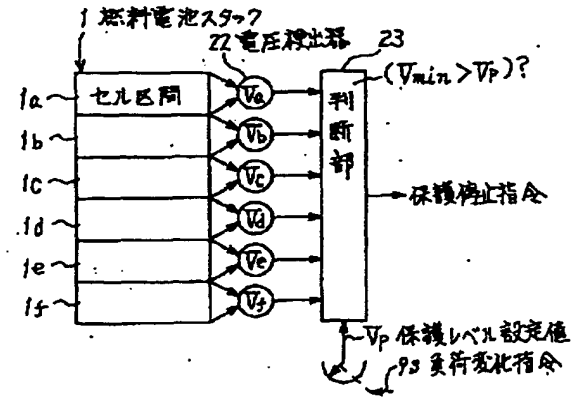
DRAWINGS

[Drawing 1]



[Drawing 2]



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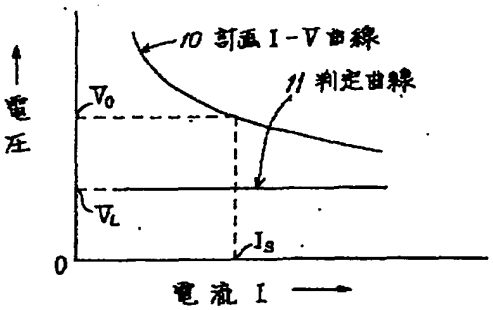

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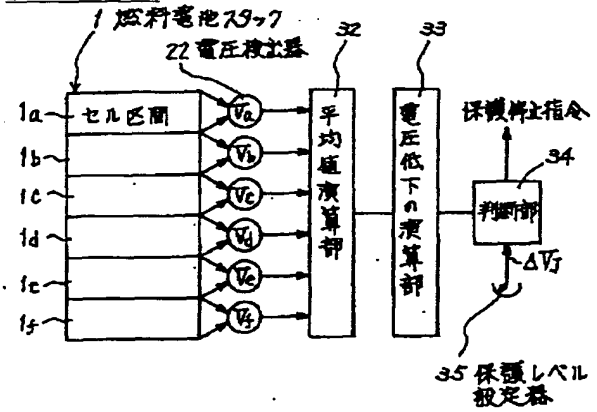

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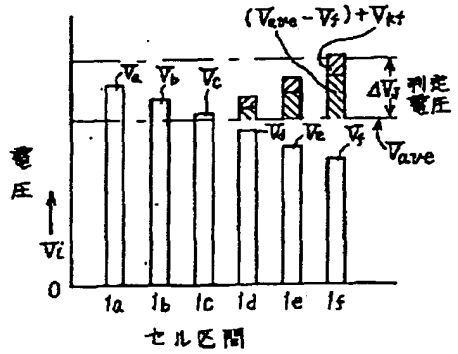
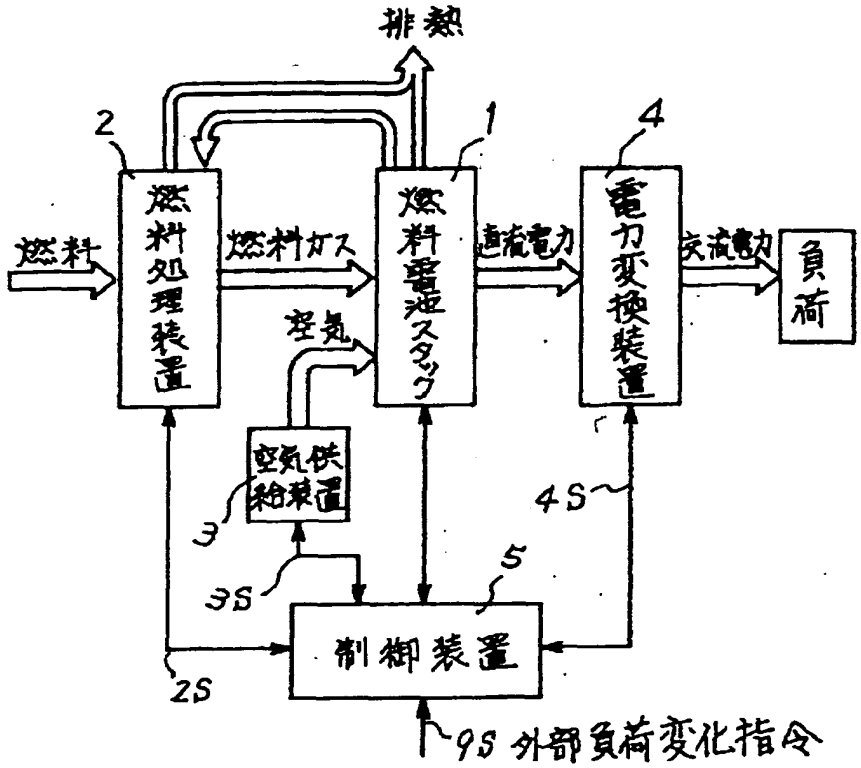


[Drawing 5]



[Translation done.]

3-03052-Y5

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（A）　(11)特許出願公開番号

特開平6－243882

(43)公開日　平成６年(1994)９月２日

(51)Int.Cl.[5]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｍ　8/04	Ｈ Ｓ			

審査請求　未請求　請求項の数３　ＯＬ　（全　６　頁）

(21)出願番号　特願平5－25865

(22)出願日　平成５年(1993)２月16日

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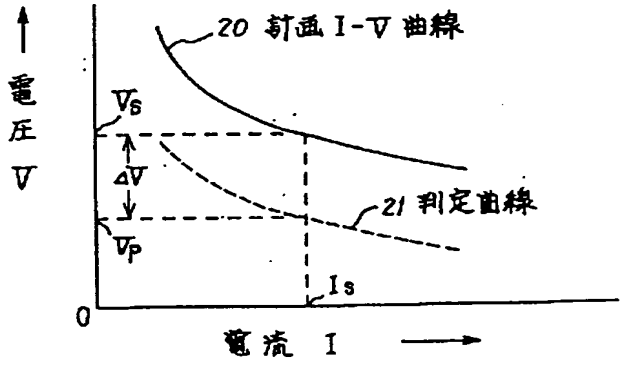
(54)【発明の名称】　燃料電池発電装置の保護停止方法

(57)【要約】
【目的】燃料電池の負荷上昇指令時に燃料電池に局部的に発生するガス不足状態を早期に検知して保護停止することにより、燃料電池の損傷を回避する。
【構成】燃料電池スタックの出力電圧を複数単位セルをセル区間として複数のセル区間について検出し、検出電圧の最低値が負荷電力の大きさに係わりなく一定電圧低下したとき保護停止する。例えば、セル区間の計画Ｉ－Ｖ曲線２０を一定電圧ΔＶ低い側に平行移動した曲線を電圧低下の判定曲線２１とし、所定の指令電力値Ｉｓ×Ｖｓ に対する検出電圧の最低値が、判定曲線２１上の指令電力値に対応する電圧値Ｖｐ まで低下したとき、そのセル区間でガス不足状態が発生したものと判定して保護停止する。



【特許請求の範囲】
【請求項１】単位セルの積層体からなる燃料電池スタックと、この燃料電池スタックに燃料ガスを供給する燃料処理装置、および空気供給装置と、前記燃料電池スタックの出力直流電力を負荷電力に変換して出力する電力変換装置と、前記各部を連系制御する制御装置とを含む燃料電池発電装置において、負荷上昇指令時に生ずるガス不足状態を前記燃料電池スタックの出力電圧の低下により検出して保護停止する方法であって、前記燃料電池スタックの出力電圧を複数単位セルをセル区間として複数のセル区間について検出し、検出電圧の最低値が負荷電力の大きさに係わりなく一定電圧低下したとき保護停止することを特徴とする燃料電池発電装置の保護停止方法。
【請求項２】セル区間の計画Ｉ－Ｖ特性曲線を一定電圧低い側に平行移動した曲線を電圧低下の判定曲線とし、所定の指令電力値に対する検出電圧の最低値が、判定曲線上の指令電力値に対応する電圧値まで低下したとき、セル区間電圧の最低値が一定電圧低下したものと判定して保護停止することを特徴とする請求項１記載の燃料電池発電装置の保護停止方法。
【請求項３】複数のセル区間の検出電圧の平均値、およびこの平均値と各検出電圧との差電圧を求め、得られた差電圧とセル区間毎に定まる補正電圧との和の最大値が一定電圧を越えたとき、セル区間電圧の最低値が一定電圧低下したものと判定して保護停止することを特徴とする請求項１記載の燃料電池発電装置の保護停止方法。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】この発明は、燃料電池発電装置がその運転中に負荷上昇指令を受けて出力電力を急上昇する際、燃料ガスの供給不足によるガス欠，およびこれに起因する燃料電池の損傷を回避するために行う保護停止方法に関する。
【０００２】
【従来の技術】図５は燃料電池発電装置の一般的なシステム構成図であり、単位セルの積層体からなる燃料電池スタック１を含む燃料電池発電装置は、化石燃料，炭化水素系燃料を燃料電池用アノードガスとしての水素リッチな燃料ガスに改質する燃料処理装置２と、酸化剤としての空気を燃料電池に供給する空気供給装置３と、燃料電池の出力直流電力を外部負荷が要求する形の電力に変換する電力変換装置４と、これら各部を制御する制御装置５などで構成される。
【０００３】このように構成された燃料電池発電装置の運転中における外部負荷への供給電力の上昇，降下は、制御装置５が外部負荷変化指令９Ｓを受けて燃料処理装置２および空気供給装置３に向けて発する制御信号２Ｓ，３Ｓ，電力変換装置４に向けて発する制御信号４Ｓ等によって制御され、燃料ガスおよび空気の供給量および外部負荷への供給電力が、外部負荷変化指令９Ｓに対応するそれぞれの目標値に一致するよう制御される。
【０００４】上記燃料電池発電装置の運転中に外部負荷変化指令９Ｓが負荷上昇を指令した場合、電力変換装置４はミリセカンド以下の応答速度で指令値に対応した電力を出力しようとするするが、燃料電池１は燃料処理装置２および空気供給装置３の応答速度に律せられ、上昇指令に対する燃料ガスおよび空気の供給増加に遅れが発生する。なお、燃料処理装置２および空気供給装置３の応答速度が電力変換装置４のそれに比べて遅いのは、例えば燃料処理装置ではその応答プロセスにおいて改質量増加（改質反応の増加）という化学反応を含んでいること、また、配管中でのガスの移動という物質移動の過程を含んでいるためである。
【０００５】
【発明が解決しようとする課題】燃料電池発電装置を外部負荷変化指令による電力制御で負荷上昇を行う場合、次のような問題が発生する。すなわち、外部負荷変化指令９Ｓにより燃料電池発電装置をフィードフォワード制御すると、制御装置は外部負荷変化指令に対応した目標値を設定し、制御信号４Ｓにより電力変換装置４に目標値に対応した電力の出力を指令し、制御信号２Ｓ，３Ｓにより、燃料処理装置２および空気供給装置３に目標値に対応した量の燃料ガスおよび空気の供給を指令する。ところが、前述したように燃料ガスおよび空気の供給は電気的出力の上昇に比べて応答速度が低いため、急激な負荷上昇指令に追従して燃料電池１への燃料ガスおよび空気の供給量が増加せず、燃料電池１の燃料極および空気極に一時的にガス不足状態が発生する。
【０００６】燃料電池にガス不足状態が一旦発生すると、燃料電池の発電電圧が低下するため、電力変換装置４は燃料電池の出力電流を増加させて出力電力を目標値に合わせようとし、これが原因で燃料電池１の電圧が一層低下する悪循環が発生し、ついには燃料電池がガス欠状態に至る。この場合、燃料電池の熱容量による温度上昇の遅れも、燃料電池に発電特性の温度依存性があるため負荷上昇時の電流の増加につながる。この結果、多数積層された単位セルのうち、各電極に形成された反応ガス通路の断面形状のバラツキなどにより、反応ガスの流れ難い単位セルからセル電圧が逆転したり、あるいは電極間に加わるガス圧の差が増大して電極間でガスの吹き抜けが生ずるなどの燃料電池の損傷が発生し、遂には燃料電池の連続運転が不可能になる事態に進展するという問題がり、ガス不足状態を早期に検知して燃料電池の発電運転を停止し、燃料電池の損傷を防止できる保護停止方法の確立が求められている。
【０００７】図６は燃料電池発電装置の従来の保護停止方法における保護動作の説明図であり、燃料電池スタック１のガス不足状態をその出力直流電圧の低下によって検知するために、燃料電池スタック１の計画Ｉ－Ｖ特性

曲線（計画電流－電圧特性曲線）１０に対し、保護停止の判定曲線１１として電流Ｉの大小に関わりなく一定電圧ＶＬ を設定し、燃料電池スタック１の出力直流電圧Ｖｉ が判定レベルＶＬ まで低下したとき、燃料電池にガス不足状態が発生したものと判断し、例えば電力変換装置４の出力を絞り、燃料電池スタック１の発電を停止する保護停止を行うよう構成した方法が知られている。また、燃料電池スタック１を複数の単位セルを１ブロックとする複数のセル区間に区分し、セル区間それぞれの電圧を検出し、一定電圧ＶＬ と照合し、保護停止する方法も知られている。

【０００８】しかしながら、保護停止開始の判定曲線１１が燃料電池の出力電流Ｉに無関係に一定電圧ＶＬ に固定されているために、計画Ｉ－Ｖ曲線との差電圧ΔＶ＝Ｖ０－ＶＬ （出力電圧の低下量に相当する）が低電流（低電力）領域で大きくなり、この領域でガス不足が生じた場合にはその検知が大幅に遅れ、単位セルの損傷を回避できないという問題が発生する。また、過渡的にある部分の単位セルのみに電圧低下を生ずる場合を想定して、燃料電池スタック１を複数のセル区間に区分して電圧を検出するよう構成した場合においても、低電流領域で差電圧ΔＶが大きいことが障害となり、この領域でのガス不足状態の検出が大幅に遅れ、単位セルの損傷を十分には回避できないという問題が発生する。

【０００９】この発明の目的は、燃料電池の負荷上昇指令時に燃料電池スタックに局部的に発生するガス不足状態を早期に検知して保護停止することにより、燃料電池の損傷を回避することにある。

【００１０】

【課題を解決するための手段】上記課題を解決するために、この発明によれば、単位セルの積層体からなる燃料電池スタックと、この燃料電池スタックに燃料ガスを供給する燃料処理装置、および空気供給装置と、前記燃料電池スタックの出力直流電力を負荷電力に変換して出力する電力変換装置と、前記各部を連系制御する制御装置とを含む燃料電池発電装置において、負荷上昇指令時に生ずるガス不足状態を前記燃料電池スタックの出力電圧の低下により検出して保護停止する方法であって、前記燃料電池スタックの出力電圧を複数単位セルをセル区間として複数のセル区間について検出し、検出電圧の最低値が負荷電力の大きさに係わりなく一定電圧低下したとき保護停止することとする。

【００１１】また、セル区間の計画Ｉ－Ｖ曲線を一定電圧低い側に平行移動した曲線を電圧低下の判定曲線とし、所定の指令電力値に対する検出電圧の最低値が、判定曲線上の指令電力値に対応する電圧値まで低下したとき、セル区間電圧の最低値が一定電圧低下したものと判定して保護停止することとする。さらに、複数のセル区間の検出電圧の平均値、およびこの平均値と各検出電圧との差電圧を求め、得られた差電圧とセル区間毎に定まる補正電圧との和の最大値が一定電圧を越えたとき、セル区間電圧の最低値が一定電圧低下したものと判定して保護停止することとする。

【００１２】

【作用】この発明のにおいて、燃料電池スタックの出力電圧が負荷電力の大きさに係わりなく一定電圧低下したとき保護停止するよう構成したことにより、低電流領域でのガス不足状態を早期に検出できないという従来技術の問題点を排除し、全ての負荷領域でガス不足状態を早期に検知して燃料電池の損傷を防止する機能が得られる。また、複数単位セルをセル区間として複数のセル区間について電圧の低下を検出し、検出電圧の最低値が一定電圧低下したとき保護停止するよう構成したことにより、限られた単位セルで発生したガス不足状態をも迅速かつ高感度で検出して単位セルの損傷を防止する機能が得られる。

【００１３】また、セル区間の計画Ｉ－Ｖ曲線を一定電圧低い側に平行移動した曲線を電圧低下の判定曲線とし、所定の指令電力値に対する検出電圧の最低値が、判定曲線上の指令電力値に対応する電圧値まで低下したとき保護停止するよう構成すれば、燃料電池スタックの初期特性として補償された計画Ｉ－Ｖ曲線に基づいて一定電圧低い保護停止の判定レベルを全ての負荷領域に渡って精度よく設定できるとともに、電力上昇指令の指令電力値に対応する保護電圧値を判定曲線上から容易に選択できるので、セル区間電圧の出力電圧の最低値が選択された保護電圧値まで低下したとき保護停止を行うことにより、ガス不足の発生をセル区間単位で早期に検出し、単位セルの損傷を防止する機能が得られ、かつ計画Ｉ－Ｖ曲線と判定曲線の間に保持する一定の電圧差の決め方により、保護停止するガス不足状態の程度を調整する機能も得られる。

【００１４】さらに、複数のセル区間の検出電圧の平均値、およびこの平均値と各検出電圧との差電圧を求め、得られた差電圧とセル区間毎に定まる補正電圧との和の最大値が一定電圧を越えたとき、セル区間電圧の最低値が一定電圧低下したものと判定して保護停止するよう構成すれば、負荷上昇指令による出力電力の増加に反比例して下降過程にある各セル区間の検出電圧の平均値を基準にして、電圧上昇の最も遅いセル区間を検出し、かつそのセル区間におけるセル温度，燃料ガスの流れ易さなど電圧のバラツキ要因を補正電圧を加えることによって補正し、なおかつ平均値に対する電圧差（電圧低下）が一定電圧を越えたとき保護停止するので、負荷上昇指令直後に過渡的に生ずる供給ガスの過不足状態を電圧の過渡的変化としてセル区間毎にリアルタイムで監視し、木目細かい状況判断に基づいて保護停止を行うことが可能となり、局所的，経時的なセルの特性低下を迅速に検知してセルの損傷を最小限に抑制する機能が得られるとともに、保護停止が掛からない状態ではガス不足による燃

料電池の損傷を懸念することなく、燃料電池発電装置を安全な継続運転状態に保持する機能が得られる。

【００１５】

【実施例】以下、この発明を実施例に基づいて説明する。図１はこの発明の実施例になる燃料電池発電装置の保護停止方法における保護動作の説明図、図２は実施例になる保護停止方法を示すシステム構成図であり、従来技術と同じ構成部分には同一参照符号を付すことにより、重複した説明を省略する。実施例になる燃料電池発電装置の保護停止方法においては、図に示すように燃料電池スタック１を複数の単位セルを単位として複数のセル区間１a, １b, １c，・・１f 等１i に区分し、複数の電圧検出器２２によりそれぞれのセル区間の電圧Va, Vb, Vc,・・Vn等１i を検出し、判断部２３において各検出電圧をあらかじめ定まる保護レベルの設定値Vp と照合し、負荷変化指令９s により燃料電池スタックの出力電力を急増する過程で、セル区間電圧Va, Vb, Vc,・・Vf 等のいずれかが保護レベル設定値にまで低下したとき、いずれかのセル区間にガス不足状態が発生したものと判断して保護停止するよう構成される。

【００１６】この実施例の場合、保護レベルの設定値Vp の決め方としては、図１に示すように、初期セル区間電圧に対応する計画Ｉ－Ｖ曲線２０を基準とし、この曲線を一定電圧ΔＶ低い側に平行移動した曲線を電圧低下の判定曲線２１として設定する。負荷変化指令９s による所定の指令電力値をＩs ×Vs とした場合、電流Ｉs に相応する判定曲線２１上の電圧値Vp が保護レベル設定値として判断部２３に自動設定され、電圧検出器２２の検出電圧Va, Vb, Vc,・・Vf と保護レベル設定値Vp とがそれぞれ照合される。

【００１７】燃料電池スタック１の出力電流がＩs より小さい負荷領域で電流をＩs に増加する負荷上昇指令９s を受けた場合、制御部５（図５参照）が発する制御信号４Ｓにより電力変換装置４に目標値に対応した電力の出力を指令し、制御信号２ｓ，３ｓにより、燃料処理装置２および空気供給装置３に目標値に対応した量の燃料ガスおよび空気の供給を指令することにより、燃料電池スタック１の出力電流が増加するに伴い、各セル区間の電圧Va, Vb, Vc,・・Vf が目標電圧Vs に向けて変化する。しかし、セル区間相互間には単位セルの温度上昇の遅れや、反応ガス通路の断面形状のバラツキなどにバラツキがあり、悪条件が重なった単位セルでガス不足が発生し、これに伴ってこの単位セルを含むセル区間電圧の低下幅が大きくなり判定曲線２１に近づく。従って、このガス不足状態となったセル区間電圧が判定レベルの設定値Vp に一致するよう、計画Ｉ－Ｖ曲線２０と判定曲線２１との電圧差ΔＶを設定しておけば、検出電圧の最低値を早期に検知して燃料電池スタックを保護停止することが可能になり、単位セルの損傷を最小限に抑えることができるとともに、保護停止が掛からない状態では燃料電池発電装置を安心して継続運転できる信頼性の高い保護停止方法が得られる。なお、計画Ｉ－Ｖ曲線と判定曲線の間に保持する一定の電圧差ΔＶを可変にすれば、保護停止するガス不足状態の程度を調整できる利点も得られる。

【００１８】図３はこの発明の異なる実施例になる燃料電池発電装置の保護停止方法を示すシステム構成図、図４は異なる実施例になる保護停止方法における保護動作の説明図である。図において、燃料電池スタック１を例えば１a, １b, １c，・・１nなどn個のセル区間に区分し、電圧検出器２２でそれぞれ検出されたセル区間電圧Va, Vb, Vc, Vd, Ve, Vf 等n個の検出値は、平均値演算部３２でその平均値Vave ＝Va+Vb+Vc+Vd+Ve+Vf ・・／nが求められる。次いで、電圧低下の演算部３３において検出電圧の平均値Vave に対する各検出電圧の低下量およびその補正（Vave －Vi ）＋Vki（添字ｉは任意のセル区間を示す）が計算される。ただし、補正電圧Vkiは、セル区間相互の温度差，燃料ガスの流れ易さ，などの初期条件の差がセル区間電圧に及ぼす影響を考慮して予め決められる。また、上記検出電圧の低下量の計算は平均値Vave より低い検出電圧に対してのみ行うよう構成されてよい。

【００１９】計算結果は判断部３４に送られて保護レベル設定器３５に予め設定された判定電圧ΔVj と照合され、図４に示すように例えばセル区間１f が（Vave －Vf）＋Vkf≧ΔVj を満たす状態となったとき、セル区間１f にガス不足状態が発生したものと判断し、判断部が保護停止指令を発するよう構成される。このように構成された保護停止方法においては、負荷上昇指令による出力電力の増加に反比例して下降過程にある各セル区間の検出電圧の平均値Vave を基準にして、電圧上昇の最も遅いセル区間（図では１f ）を平均値Vave に対する検出電圧の低下分として検出し（Vave －Vi ）、かつそのセル区間におけるセル温度，燃料ガスの流れ易さなど電圧のバラツキ要因を補正電圧Vkiを加えることによって補正し、なおかつ平均値に対する電圧差（Vave －Vi ）＋Vkiが判定電圧ΔVj を越えたとき保護停止するので、負荷上昇指令直後に過渡的に生ずる供給ガスの過不足状態を電圧の過渡的変化としてセル区間毎にリアルタイムで監視し、木目細かい状況判断に基づいて保護停止を行うことが可能となり、局所的，経時的なセルの特性低下を検知してセルの損傷を最小限に抑制する機能が得られるとともに、保護停止が掛からない状態ではガス欠やこれに伴う燃料電池の損傷を懸念することなく負荷の上昇，下降制御を行えるとともに、燃料電池発電装置を安全に継続運転できる利点が得られる。

【００２０】

【発明の効果】この発明は前述のように、燃料電池スタックの出力電圧を複数単位セルをセル区間として複数のセル区間について検出し、検出電圧の最低値が負荷電力

の大きさに係わりなく一定電圧低下したとき保護停止するよう燃料電池の負荷上昇時における保護停止方法を構成した。その結果、低電流領域でのガス不足状態を早期に検出できないという従来技術の問題点を排除し、全ての負荷領域でガス不足状態を早期に検知して燃料電池の損傷を防止できるとともに、限られた単位セルで過渡的に発生するガス不足状態をも迅速かつ高感度で検出して単位セルの特性低下を防止できる燃料電池発電装置の保護停止方法を提供することができる。

【００２１】また、保護停止が掛からない状態ではガス欠やこれに伴う燃料電池の損傷を懸念することなく負荷の上昇，下降制御を行えるとともに、燃料電池発電装置を安全に継続運転できる利点が得られる。

【図面の簡単な説明】

【図１】この発明の実施例になる燃料電池発電装置の保護停止方法における保護動作の説明図

【図２】実施例になる保護停止方法を示すシステム構成図

【図３】この発明の異なる実施例になる燃料電池発電装置の保護停止方法を示すシステム構成図

【図４】異なる実施例になる保護停止方法における保護動作の説明図

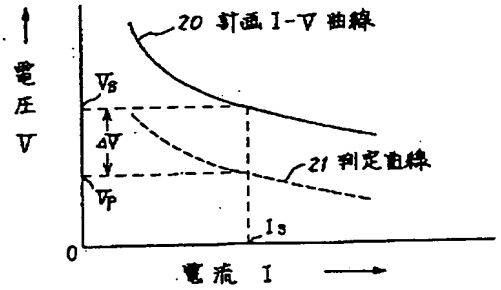
【図５】燃料電池発電装置の一般的なシステム構成図

【図６】燃料電池発電装置の従来の保護停止方法における保護動作の説明図

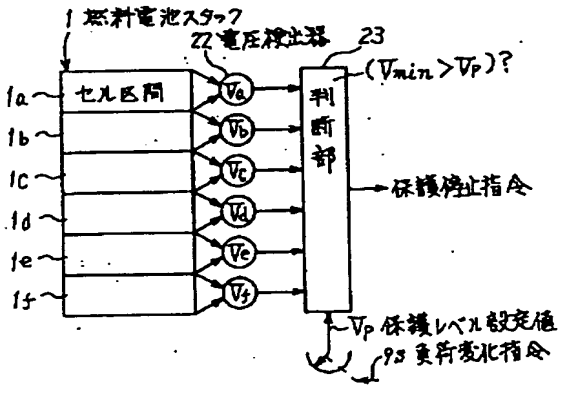
【符号の説明】

1　燃料電池スタック
1i　セル区間
2　燃料処理装置
3　空気供給装置
4　電力変換装置
5　制御装置
9s　負荷変化指令
１０　計画Ｉ－Ｖ特性曲線
１１　判定曲線
２０　計画Ｉ－Ｖ特性曲線
２１　判定曲線
２２　電圧検出器
２３　判断部
３２　平均値演算部
３３　電圧低下の演算部
３４　判断部
３５　保護レベル設定器
Vs　セル区間電圧（指令値）
Is　出力電流（指令値）
Vp　保護レベル設定値
ΔV　電圧低下幅（判定電圧）
Vave　検出電圧の平均値
Vf　セル区間電圧（セル区間１f の検出値）
Vkf　セル区間１f の補正電圧
ΔVj　電圧降下幅（判定電圧）

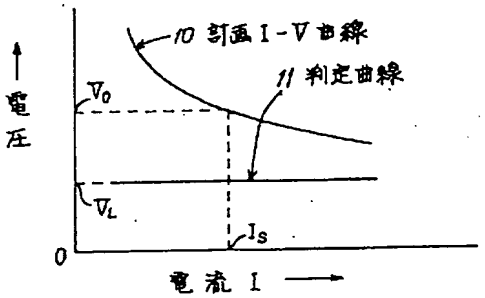
【図１】



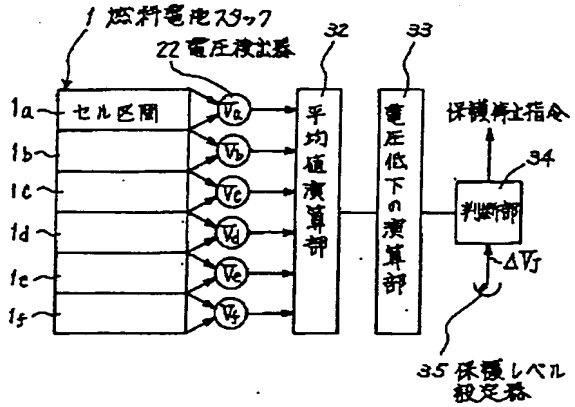
【図２】



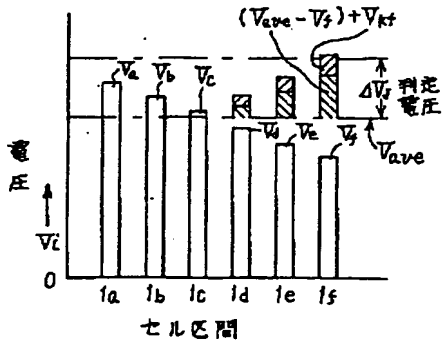
【図６】



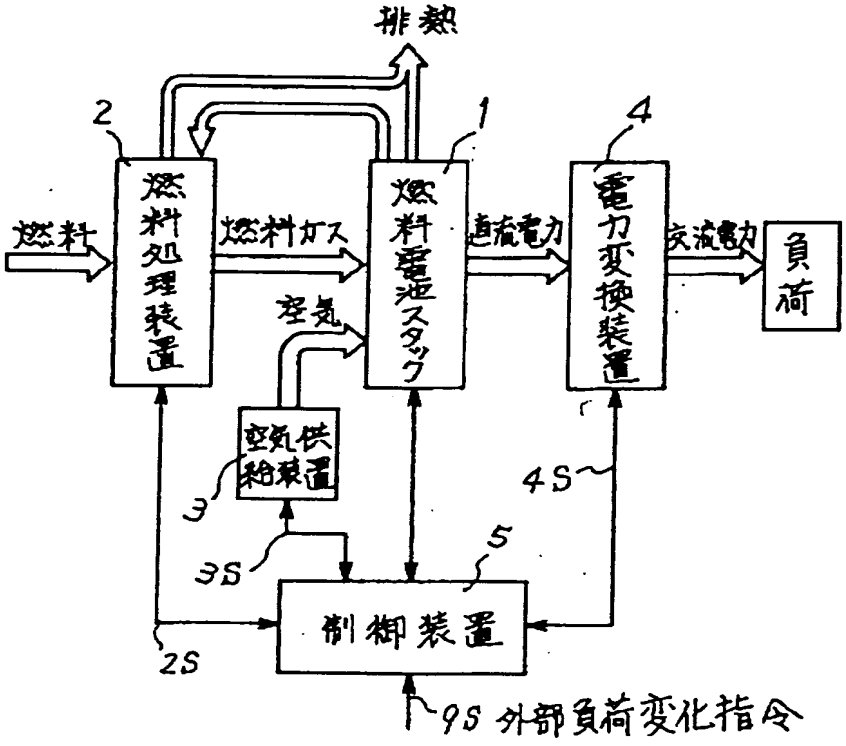
【図3】


1 燃料電池スタック
22 電圧検出器
32
33
1a
1b
1c
1d
1e
1f
セル区間
Va
Vb
Vc
Vd
Ve
Vf
平均値演算部
電圧低下の演算部
保護停止指令
34
判断部
ΔVf
35 保護レベル設定器

【図4】


(Vave-Vf)+Vkt
Va
Vb
Vc
Vd
Ve
Vf
ΔVf
判定電圧
Vave
電圧
Vi
0
1a
1b
1c
1d
1e
1f
セル区間

【図5】


排熱
2
1
4
燃料
燃料処理装置
燃料ガス
燃料電池スタック
直流電力
電力変換装置
交流電力
負荷
空気
空気供給装置
3
3S
4S
5
制御装置
2S
9S 外部負荷変化指令

L F=P008 C

＊＊検索回答[S1　　]＊＊ ファイル(P) 様式(P008) 2003/01/30　　1/　　1
*** 特許出願 平05- 25865[H 5. 2.16]　　請求( )　出願種別 (通常　) ***
特開平06-243882[H 6. 9. 2] 特公　　[　　] 登録　　[　　]
公報発行日[　　]

名称　燃料電池発電装置の保護停止方法
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ＩＰＣ H01M 8/04　　H01M 8/04
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優先権 ( ) [　　] (　　) [　　] (　　)
関連種別 (　　) 原出願番号 (　　) 原登録番号 (　　)
基準日 (出願日) [平 5. 2.16]　遡及日[　　] ( )
審査異議有効数 ( )　請求項の数 (003)　権利譲渡／実施許諾 ( )
査定種別 (-)[　　] 最終処分 (未審査請求取下) [平12. 5.23]
審査種別 (通常審査)
審査記録　　(A63　願書　,平 5. 2.16,14000:)
(A961　職権訂正,平 5. 4. 8,　:)(A300　未請求票,平12. 5. 9,　:)
*** 審判　　[　　] 種別[ ] ***
審判請求人　-
請求人代理人　(　　)　異議有効数 (　　)
被請求人　-
異議申立人 ( ) -
異議申立請求項( )( )　異議決定種別( )[　　]
審判最終処分( ) 確定日[　　]
異議決定分類 ( ) - - -　- -　-
審決分類　- - -　- -　-
審判／異議記録
登録記録
最終納付年分
本権利抹消日 [　　]　閉鎖登録日 [　　]
権利者　-